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THEORETICAL PROBLEMS IN THE DEVELOPMENT OF MODELS OF THE SYSTEM OF THE SCIENCES

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH

DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc ccsec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}
rot	curl
lg	log

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E. Bona and Y. Farkash (VNR) Hungarian People's Republic

THEORETICAL PROBLEMS IN THE DEVELOPMENT OF MODELS OF THE SYSTEM OF THE SCIENCES

In the modern conception of science dynamic elements, industrial and social processes, and consideration of the nature of human activity are playing an increasing role. The traditional point of view, on the other hand, sees in sciences primarily a system of results (for example, a system of knowledge, and not a system of forms of activity).

Within the framework of the traditional theory the division of science into separate branches led to an almost uncontrollable differentiation. There are many indications, however, that science may be regarded more as a "network" than as a "tree", as D. Bernal has noted.

In our own time it is the unifying rather than the separating tendencies which are significant. At the same time there still exists no fully developed theory which is capable of representing the totality of the sciences in the form of an orderly system.

On the basis of the new approach the social character of science is rendered more apparent than with the traditional approach. As science becomes a directly productive force the methods which make its efficient use possible are gaining in importance. It has become necessary to move from the traditional classification of the sciences to a higher-level systematization in which the rigid boundaries between the natural, social and engineering sciences, as well as between the basic and applied sciences, are eliminated.

The systematization of scientific disciplines should be based on the principles of coordination and subordination. The combination of these two principles is required by the fact that not one but several principles of classification and therefore several criteria must be used in elucidating the structure of the sciences. In our view the criteria which should be used in the classification of scientific disciplines may be divided into: ontological, gnosiological, methodological and functional subgroups.

These groups of criteria permit isolation of the basic structural components of science.

Models based on the branch principle are increasingly giving way to network models. The reason for this is that network models indicate the nodal points in the development of science and thus give the possibility of establishing a versatile system of interconnections between the different branches of science. Network models may also be used in the development of forecasts. The construction of network models of individual areas of scientific knowledge far transcends the boundaries of philosophy. We consider it important to note that the systematization of science even at the present time is somewhat one-sidedly regarded by some as a philosophical task. However, science is not only a logical system, it is a complex logical system, integrating, besides a purely logical mechanism, investigative activity, research facilities and methods, organizational forms, a system of human relations, etc.

The ontological criterion permits us to distinguish the social sciences from the science of thought. But even here we may assert that the distinctions between these areas of science are not only ontologically determined. Gnosiological and methodological factors are also of significance.

From the point of view of ontological criteria for the systematization of science the distinction between theoretical (basic) and practical (applied) sciences is of great importance.

The influence of the gnosiological criterion on this distinction comes not only from the fact that the applied (engineering) sciences developed later than the theoretical sciences and possess less internal closure, but also in the tendency (even today) to identify the engineering (applied) sciences with the natural sciences, as though the solution of technical problems were not a scientific activity per se.

The following remarks are relevant to the use of the gnosiological criterion in the classification of the sciences:

a) Different forms of perception form different types and groupings of scientific disciplines.

Some branches of science are regarded as experimental, others as based on positions of a logical character, others as historical etc.

b) Levels of perception are of great prognostic significance in the classification of the sciences.

A network model of a science during a given epoch always contains elements corresponding to complexes of various gnosiological levels, i.e. it contains disciplines or lines of research as well as the points at which they intersect. The ignoring of gnosiological causes of differentiation in the system of the sciences, and consequently the ignoring of the historical causes of this differentiation, is one of the major causes of vulgarization, dogmatism, etc. and the resulting erroneous conclusions and decisions.

In classifying the sciences on the basis of methodological principles it is necessary to start from the fact that method is as it were the perceived internal nature of the object, i.e. it reflects the way the subject perceives the essence of the object. In methodology the ontological is united with the gnosiological; the methodological aspect is a bridge between the ontological and the gnosiological, between object and subject. Method therefore has a particular nature, structure, independence, and so a particular concreteness.

Today we encounter many sciences whose independence is to be explained primarily by methodological causes, although here as well the attempt is made to reduce the individuality of a science to ontological factors (for example, forms of movement).

Nevertheless the question arises: is it or is it not possible to consider as independent areas of science the separate branches of investigation which are characterized mainly by methodological differences (for example, spectroscopy, photometry, gravimetry)? One of the characteristic features of our conception of the classification of science is the fact that we consider as the elements of the structure of science not only "developed" disciplines, but also lines of research, including those characterized by generality of approach.

The presence of these elements should be reflected in classification models. For this purpose network models are more appropriate than traditional hierarchical models.

The introduction of new methods into science is extremely important for its development. The conditions for such introduction are the symbiosis and hybridization of individual sciences, with the resulting formation of complex (multiple) sciences. Methodological aspects may determine the type to which a science belongs. But methodologically differentiable types having a descriptive, synthesizing, systematizing, comparative and analyzing complex character in general may be isolated only using a network

model of the state of a science in the framework of a single well-defined epoch. At the same time a type isolated on methodological grounds may be quite stable.

As regards the functional aspects of the classification of the sciences, if, on the one hand, the significance of these aspects has sometimes been exaggerated, it has, on the other hand, often been underestimated, in that those who classify sciences have attempted to reduce all considerations to objective, material, ontological ones, thereby underestimating the influence of social factors on the development of science.

The scientific-technological revolution in our time is a process in which science is becoming a directly productive force. The actualization of the slogan "production must look to science" is once again establishing functional aspects as criteria for the classification of sciences. Science does not exist without subject matter. Each science and research area includes functional factors. Therefore in defining the place of any branch of science in the system of scientific knowledge it is necessary to consider such factors.

Modelling of the structure of the system of the sciences in the form of classification requires consideration of a large number of criteria on the basis of which individual sciences may be grouped. It is therefore expedient to construct special-purpose "maps" of science on the basis of a given criterion, such as the typical make-up of research activity, the nature of the financing of this activity, ways in which labor resources are used, etc.

Functionally oriented grouping of sciences may be successfully based on network models using mathematical, mathematical-logical, and cybernetic methods and the methods of information theory.

The following considerations are relevant in this regard:

1. A major advantage of the functional approach is the fact that it presupposes a conception of science as an activity, while at the same time the representation of science by means of network models allows science to be investigated as an activity.

2. With the increasing role of functional classification criteria the "humanization" criterion, apart from the "developmental tendency" criterion, is of great importance. The "humanization" process may be defined as that whereby links are established between scientific activity and various social tasks.

3. The types of criteria suitable for the classification of the sciences which have been briefly described above themselves constitute a highly differentiated, dynamic, open system with a complex structure. The investigation of the structure of the criteria of internal and external interconnections is an important task. The correct use of the criteria of classification to a significant degree increases the prognostic role of individual models in the system of the sciences.

The conception of the classification of the sciences described above has already been used for purposes of forecasting. Thus, E. Bona, in his article "Contemporary Structure of Science and Problems in Modelling It", expressed his opinion of current classification from the point of view of the future. In another work, "Classification of the Chemical Sciences and Branches of Research", it is shown that, if a network model of the system of the unsolved problems of chemistry is constructed, then it is not difficult to find in this network elements which are "foreign" from the point of view of chemistry, such as, for example, physical,

biological, etc. elements. This is due to the fact that there exist in the structure of chemical science disciplines and lines of research (molecular biology, microbionics, spectroscopy) which have come into chemistry from other scientific structures, but which preserve their links with these structures.

E. Bona has indicated a number of points of contact between sciences and tendencies along these lines, as well as the possibility of the appearance of new areas of scientific investigation.

Y. Farkash has performed similar research, and, in his article "Structural Divisions in Science", has compared the Soviet, American, Hungarian, and German scientific records. On the basis of these materials he compiled charts showing, both in historical and future perspective, already existing and probable future points of intersection of existing scientific disciplines, as well as the appearance of new lines of research.